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Session VI. Heavy Rain Aerodynamics

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Estimate of Heavy Rain Performance Effect
Dan Vicroy, NASA Langley

The Aerodynamic Effect of Heavy Rain on Airplane Performance

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NASA / FAA Wind Shear Review Meeting
October 16-18, 1990
Hampton, Virginia

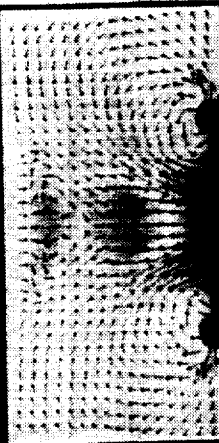
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The Aerodynamic Effect of Heavy Rain on Airplane Performance

NASA/FAA AIRBORNE WIND SHEAR PROGRAM ELEMENTS

Hazard Characterization



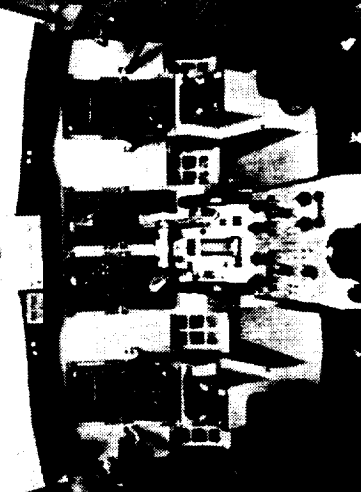
- Wind Shear Physics/Modeling
- Heavy Rain Aerodynamics
- Impact on Flight Characteristics

Sensor Technology



- 2nd Generation Reactive
- Airborne Doppler RADAR/LIDAR
- Airborne Passive INFRARED
- Sensor Information Fusion
- Flight Performance Evaluation

Flight Management Systems



- System Performance Requirements
- Guidance/Display Concepts
- TDWR Information Data Link/Display
- Pilot Factors/Procedures

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AIAA HR b/w 2

The Aerodynamic Effect of Heavy Rain on Airplane Performance

Objective:

Estimate and characterize the effect of heavy rain on the performance of a conventional twin-jet transport

Methodology:

- a) Develop a heavy rain aerodynamic model of the airplane based of 2D airfoil measurements
- b) Compute airplane performance with heavy rain model
- c) Numerically simulate a wet microburst encounter and exercise escape procedures

The Aerodynamic Effect of Heavy Rain on Airplane Performance

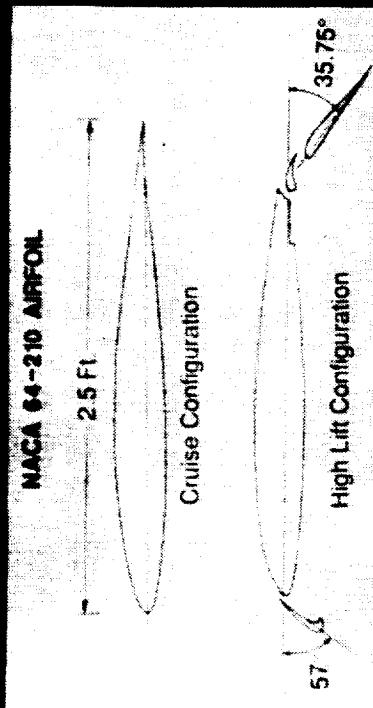
Outline

- Review of heavy rain airfoil tests
- Development of heavy rain aerodynamic model for a twin-jet transport
- Performance analysis with heavy rain effects
- Numerical simulation of wet microburst encounter
- Summary of Results & Future Needs

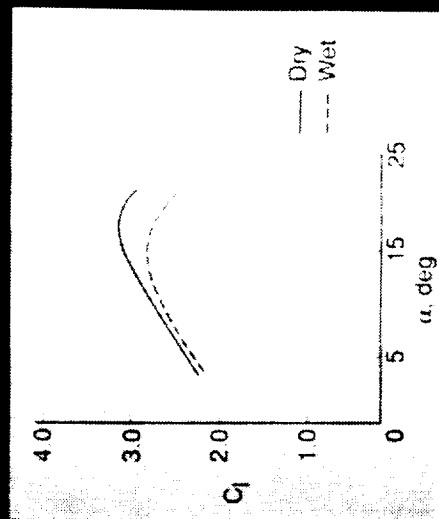
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Rain Effects on Airfoil Performance

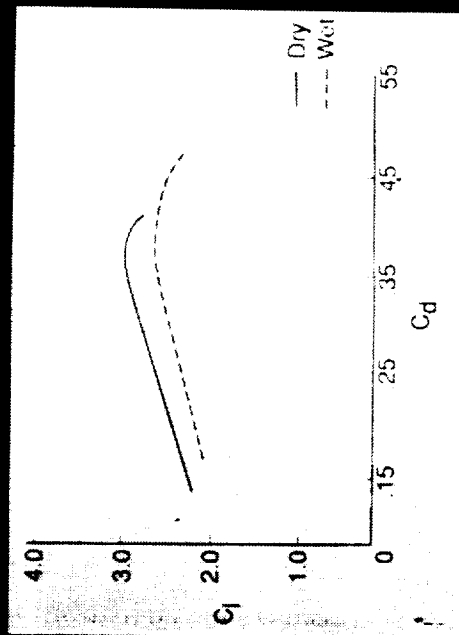
Cross Section of the Wing Model



High Lift Configuration



Test Set-up in 14 by 22 Foot Tunnel
with Simulated Rain

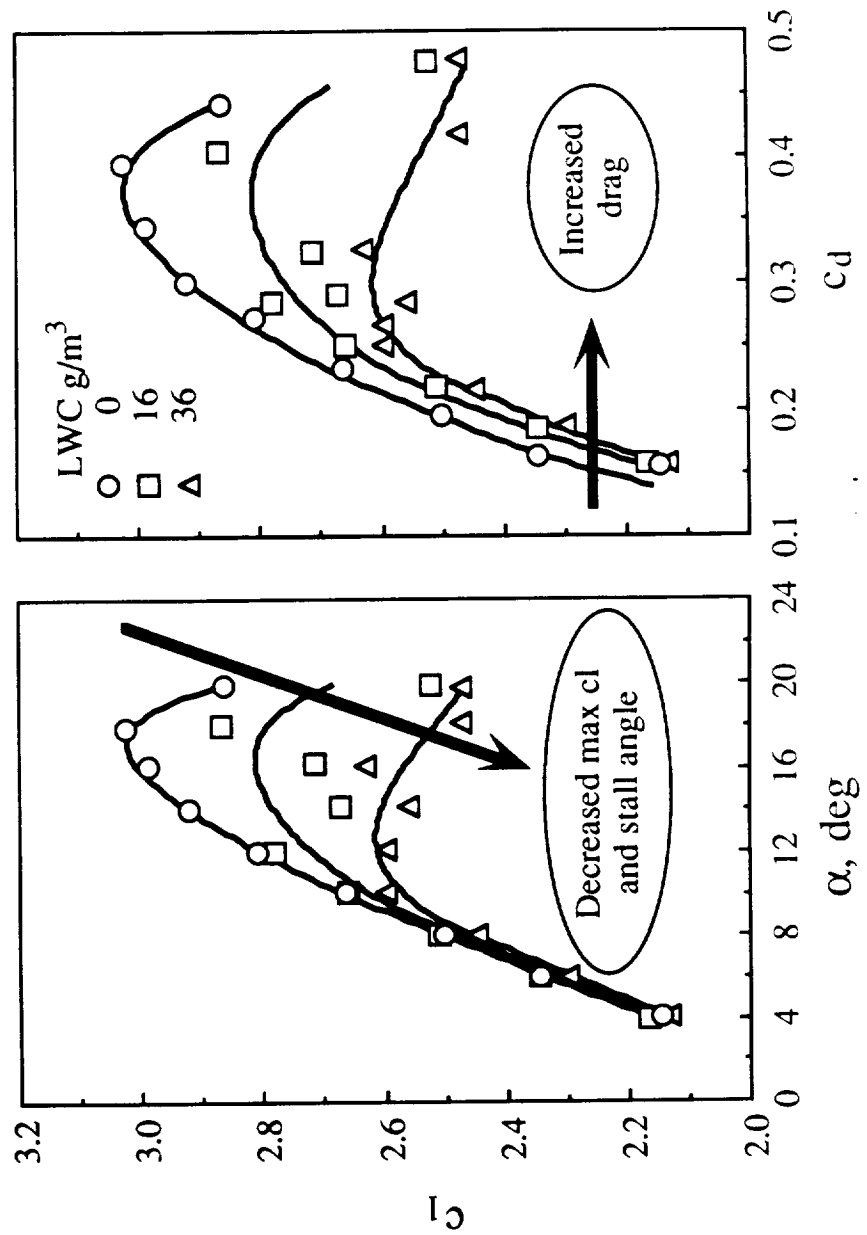


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The Aerodynamic Effect of Heavy Rain on Airplane Performance

Heavy Rain Effect on NACA 64-210 in a High Lift Configuration



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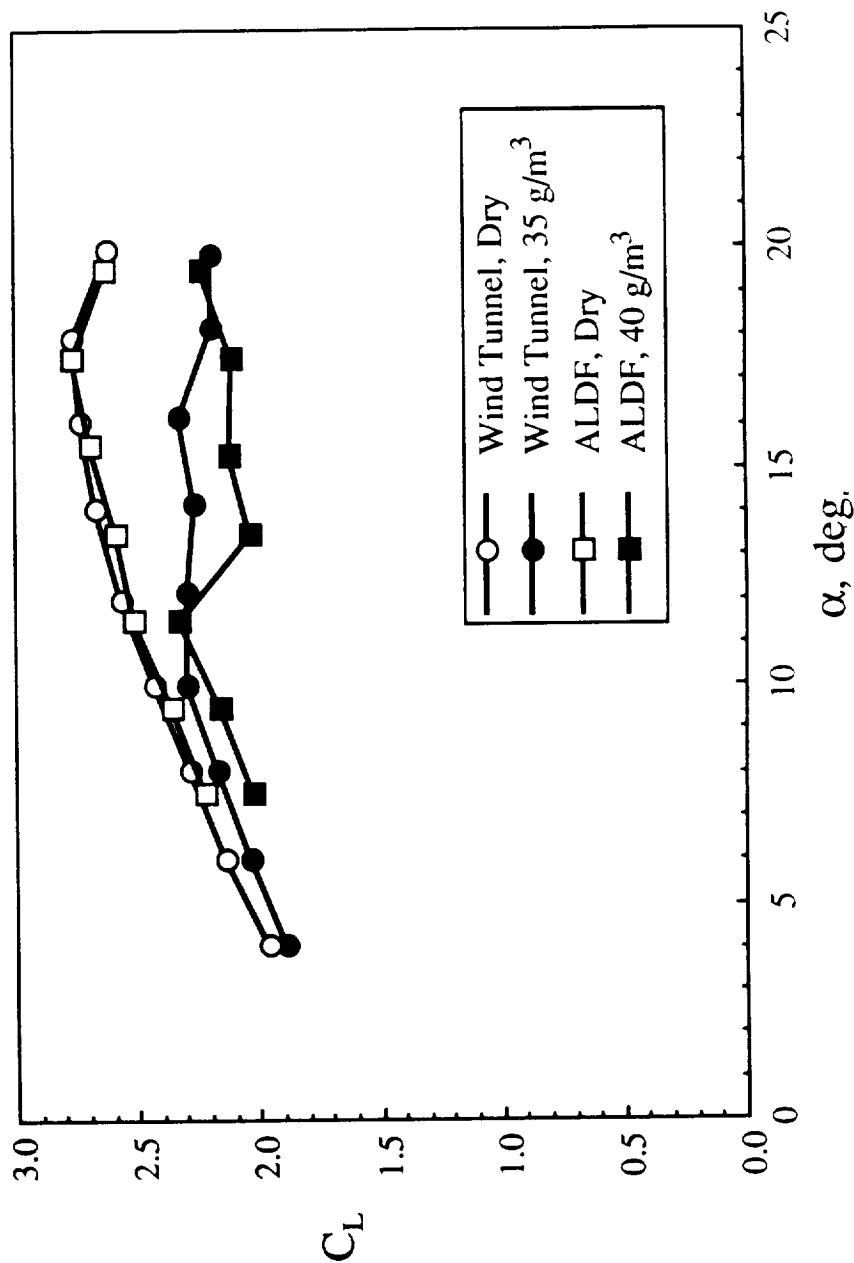


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The Aerodynamic Effect of Heavy Rain on Airplane Performance

Heavy Rain Scale Effect



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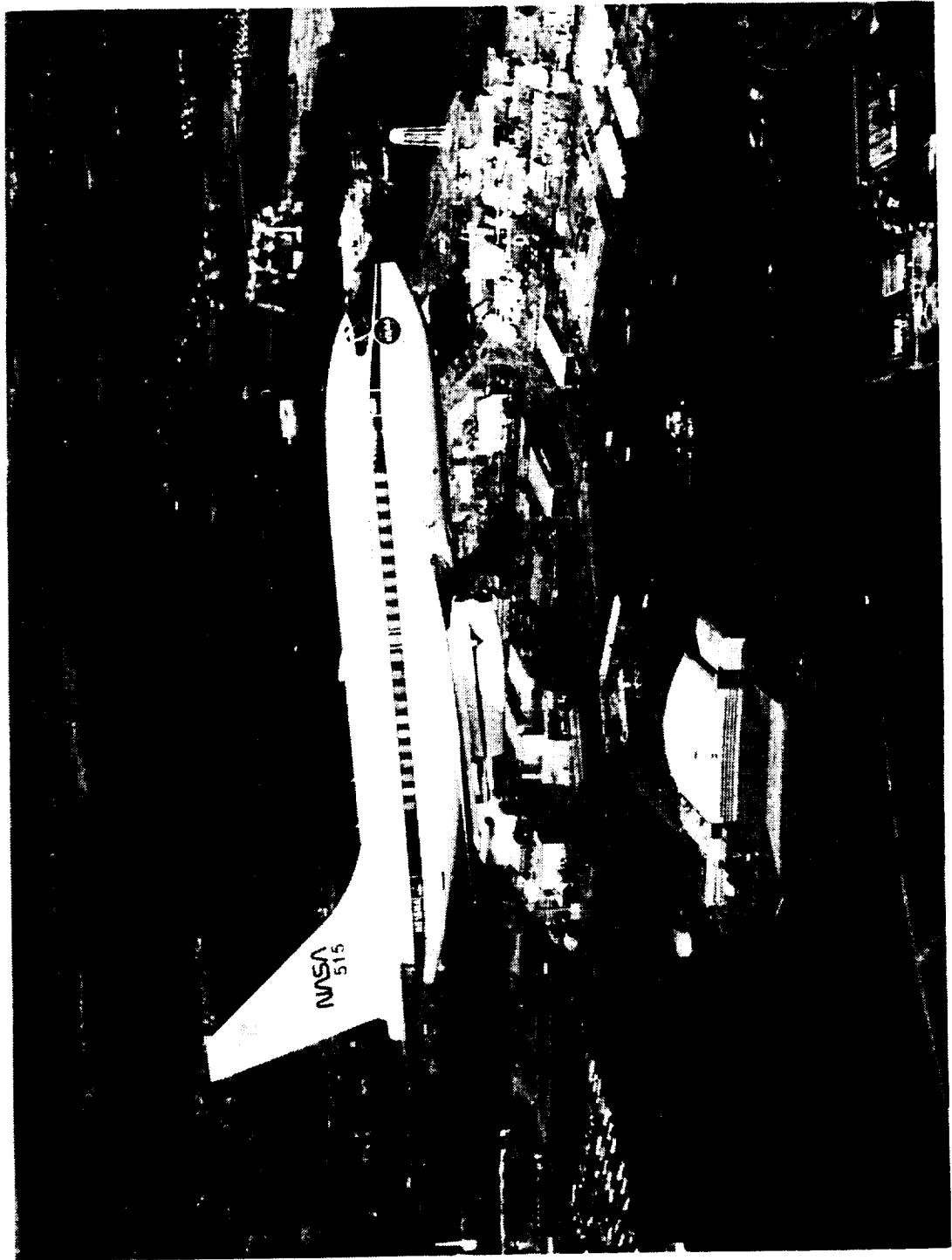
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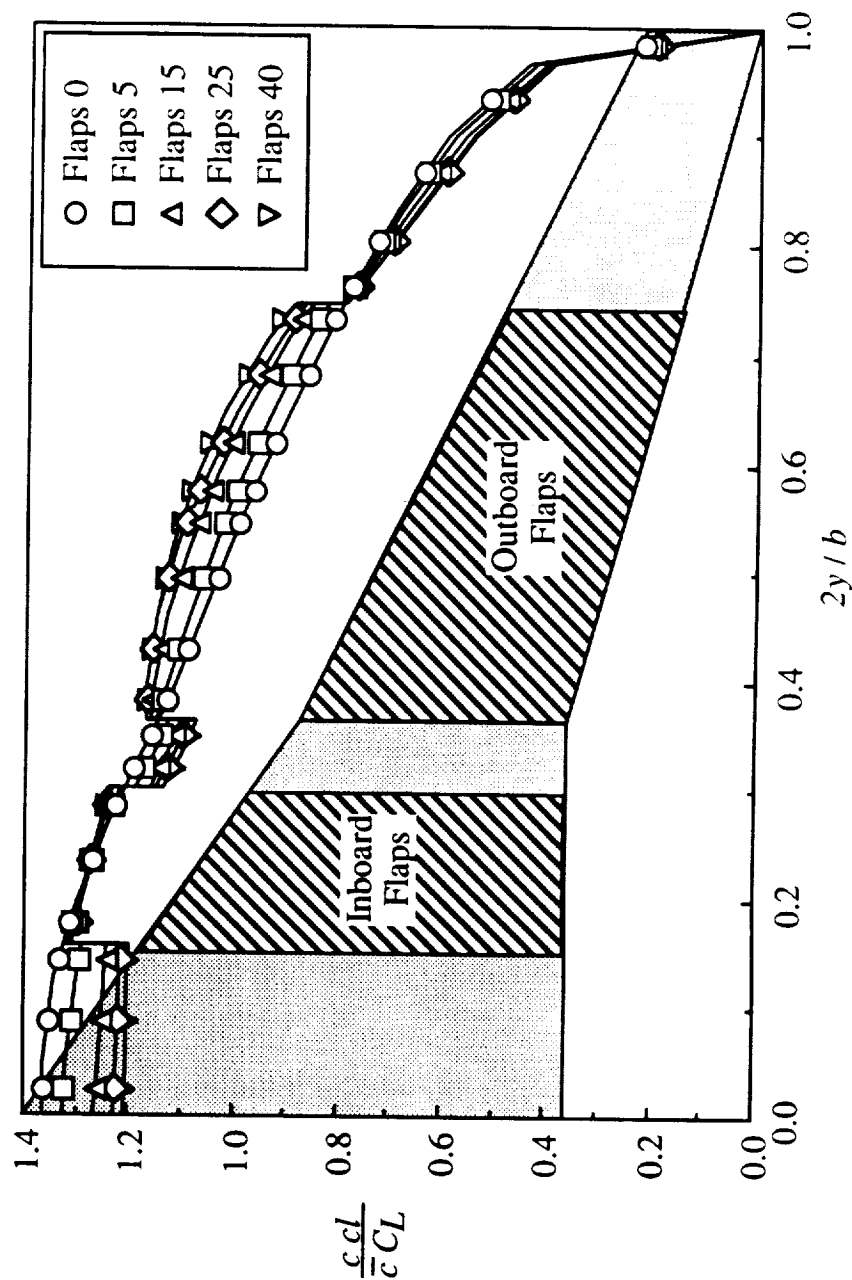


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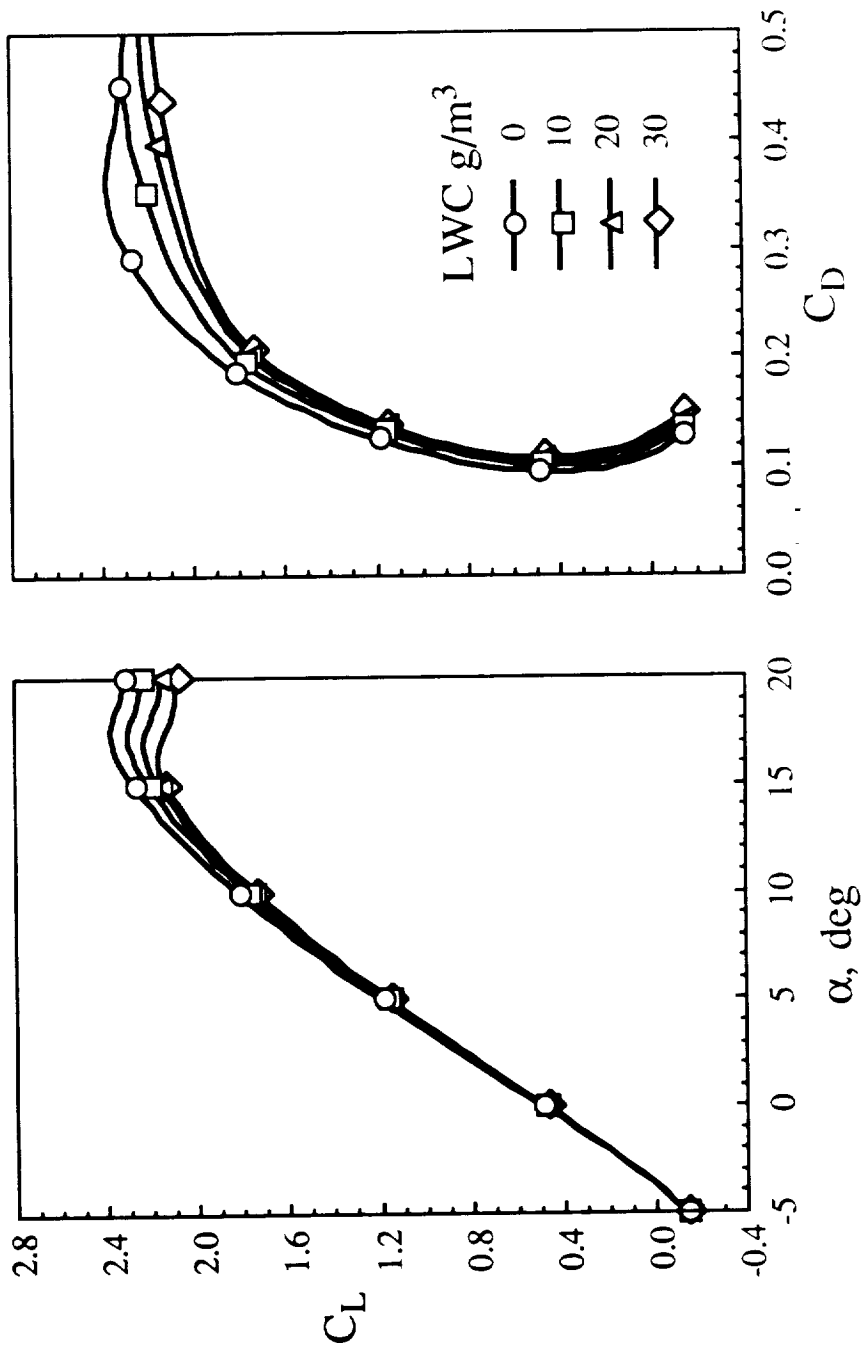
The Aerodynamic Effect of Heavy Rain on Airplane Performance

Planform Integration



The Aerodynamic Effect of Heavy Rain on Airplane Performance

Heavy Rain Aerodynamic Model (Flaps 25°, Gear Down)



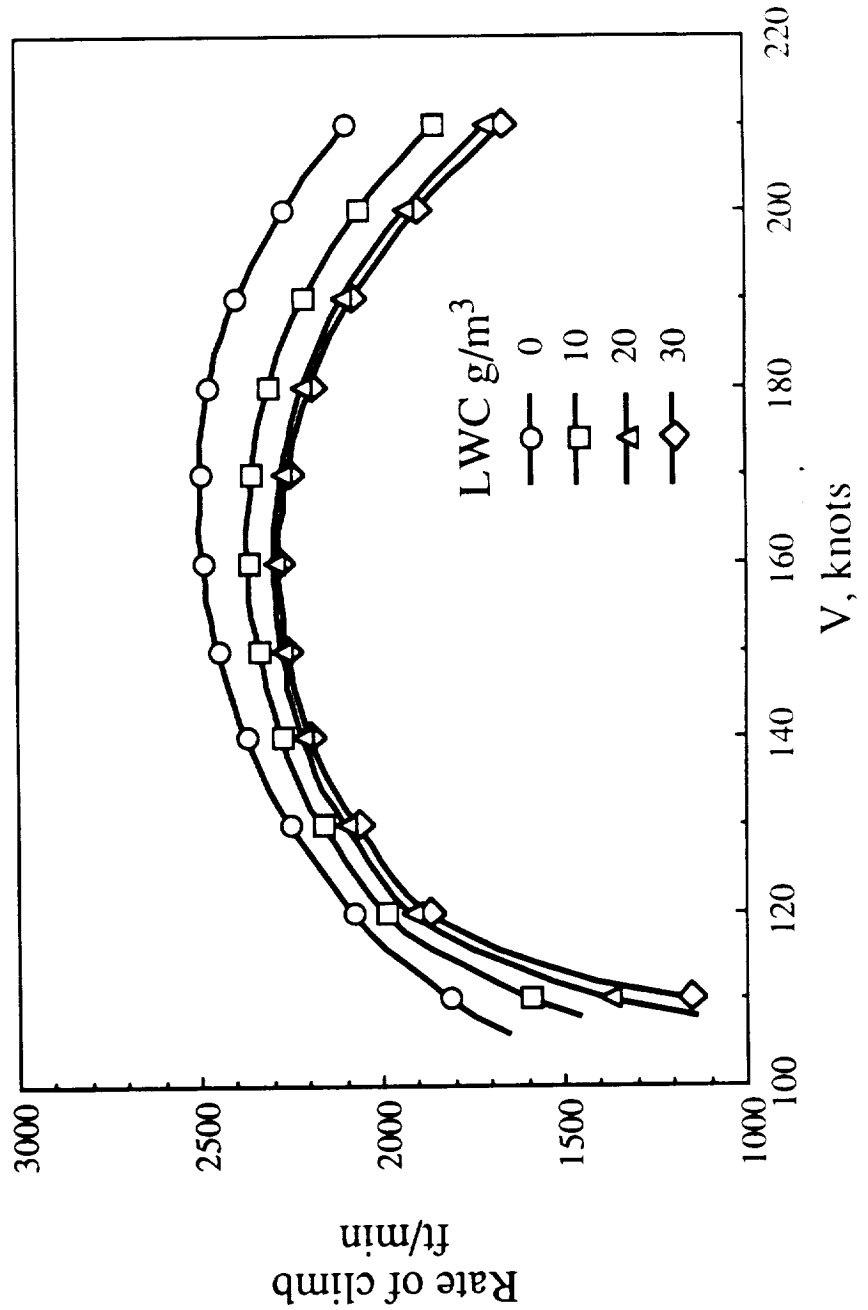
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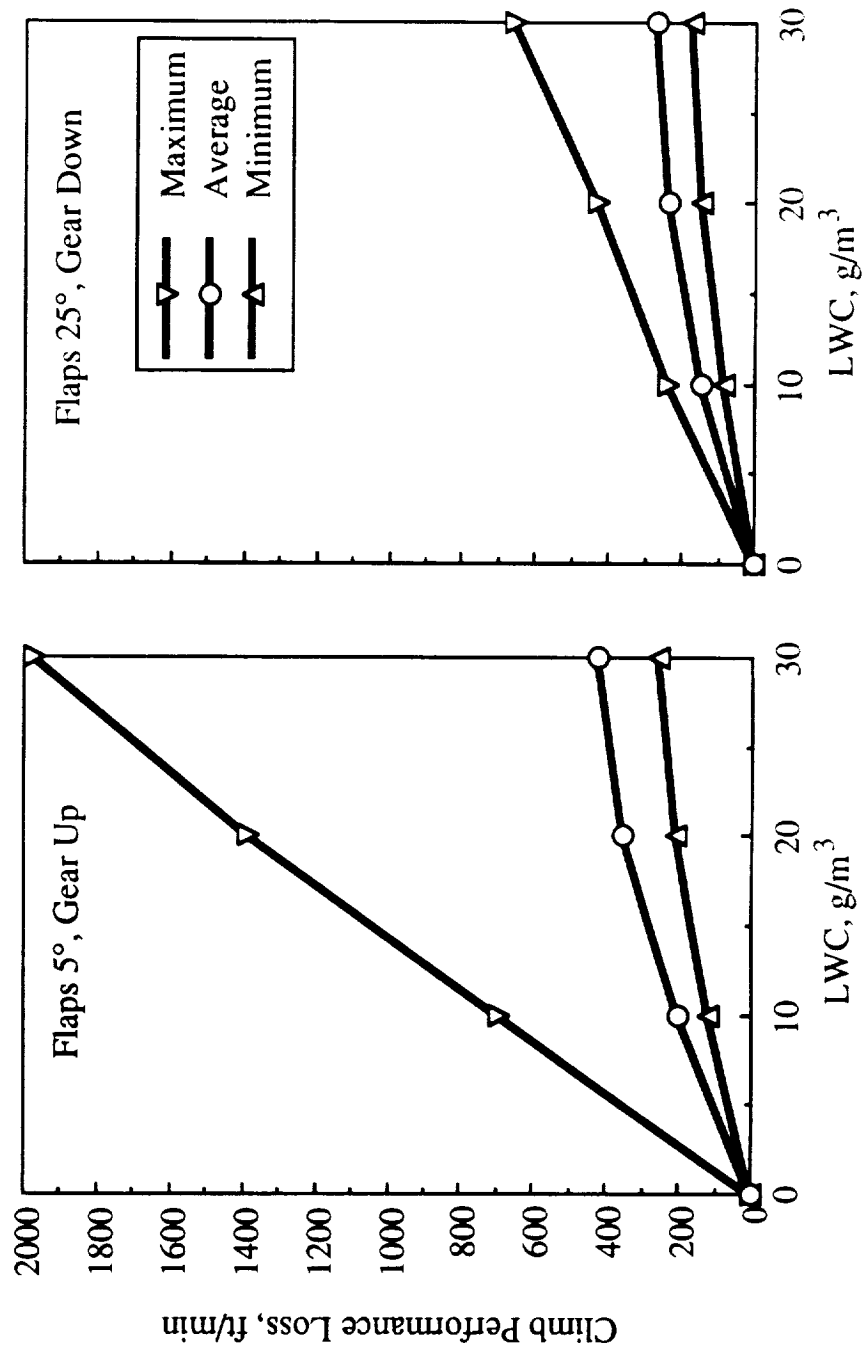
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Climb Performance in Heavy Rain (Flaps 25°, Gear Down)



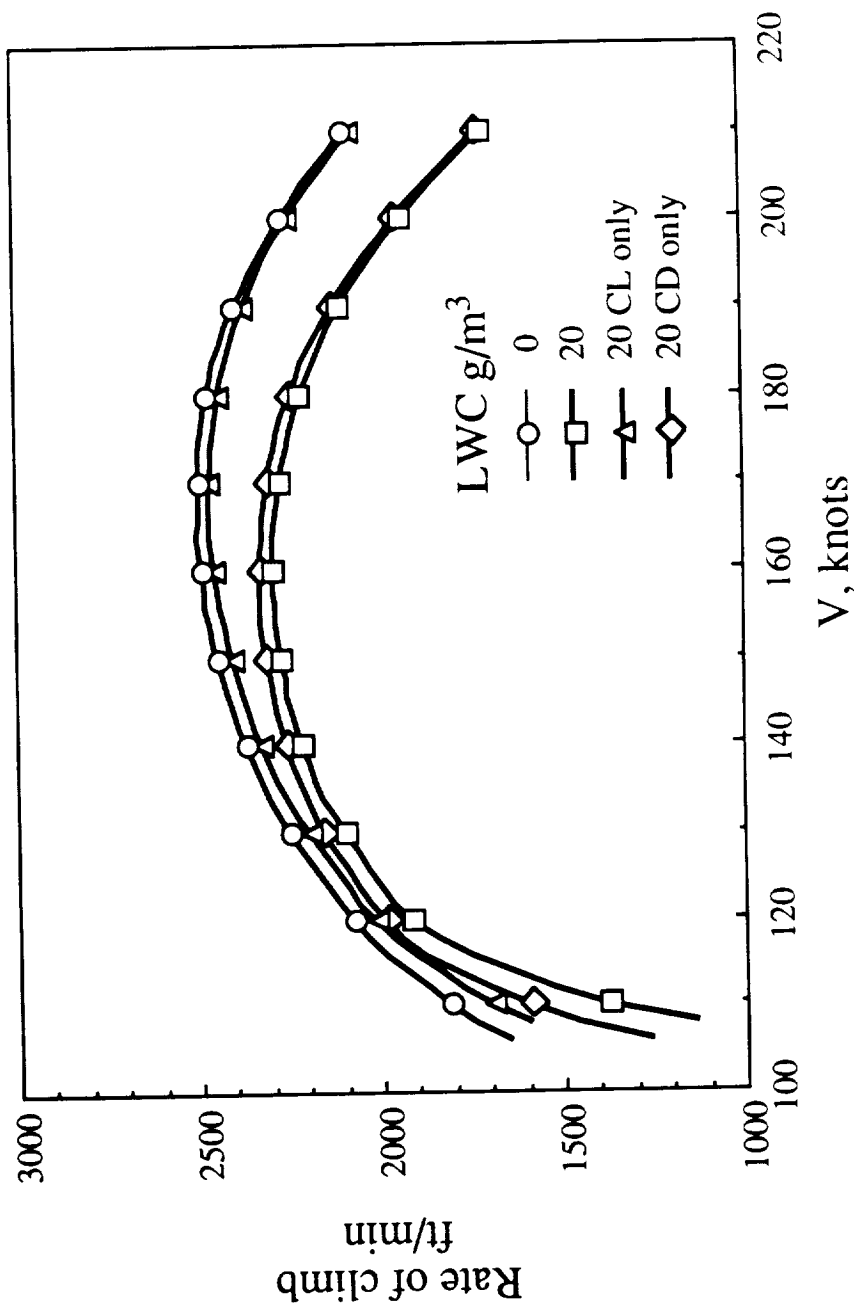
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Climb Performance Loss



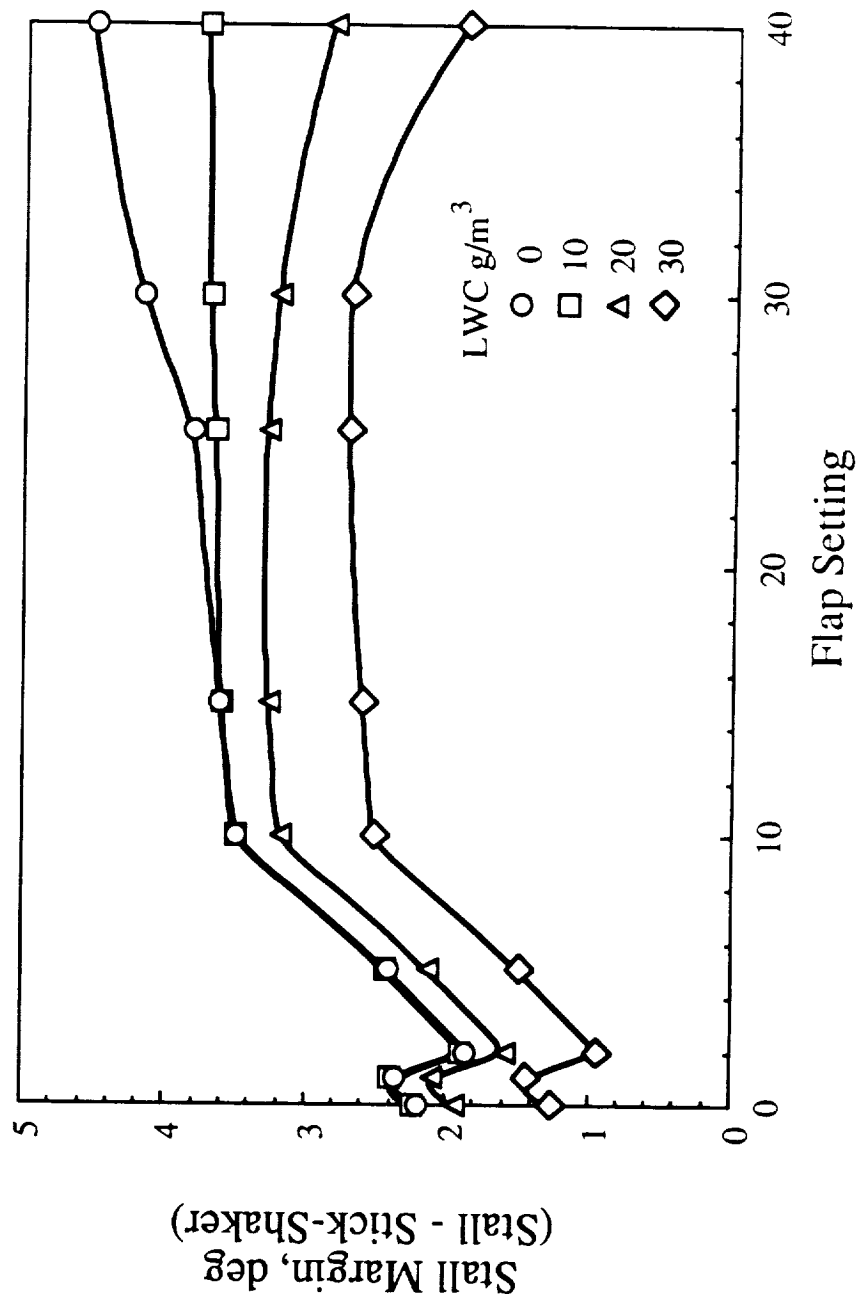
The Aerodynamic Effect of Heavy Rain on Airplane Performance

Climb Performance Sensitivity to Lift and Drag
(Flaps 25°, Gear Down)



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Stall Margin



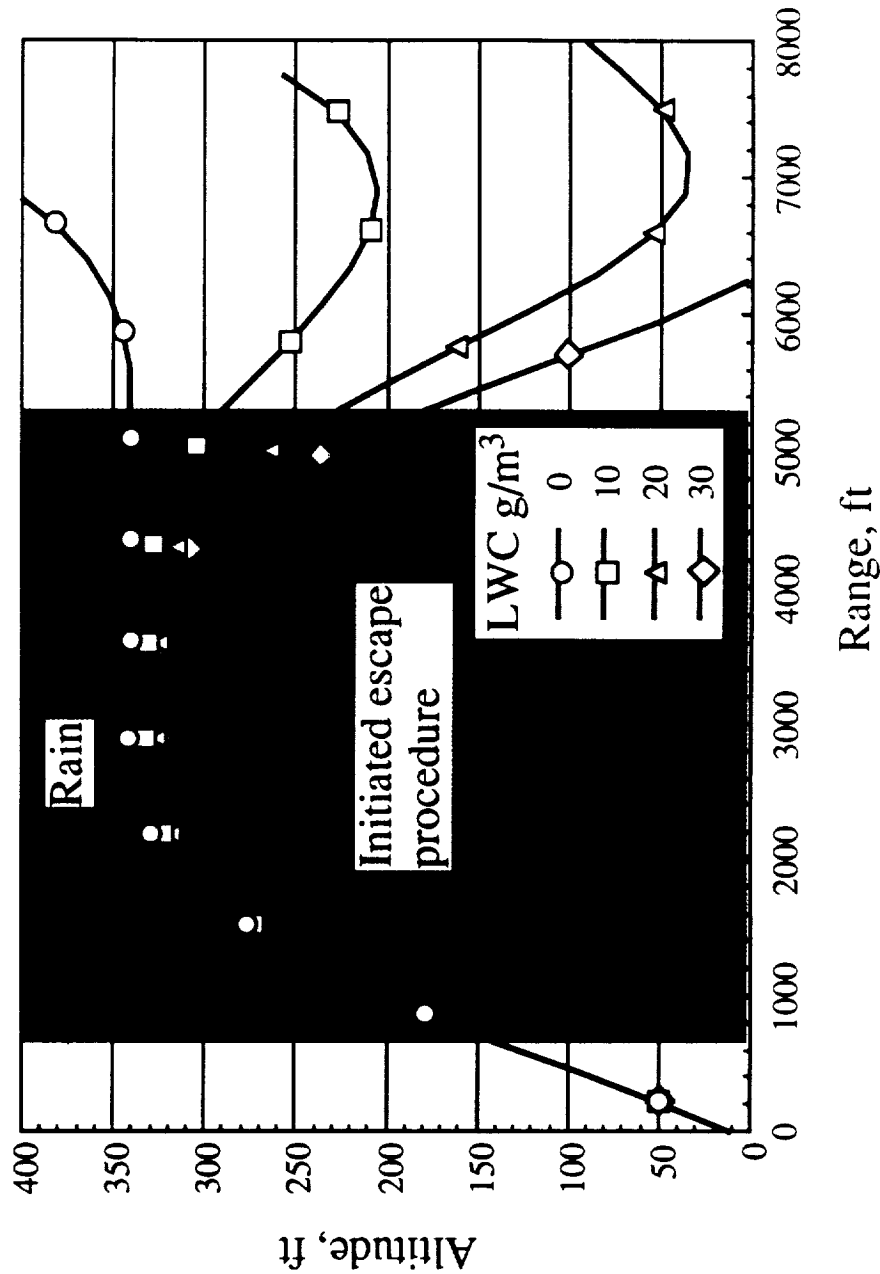
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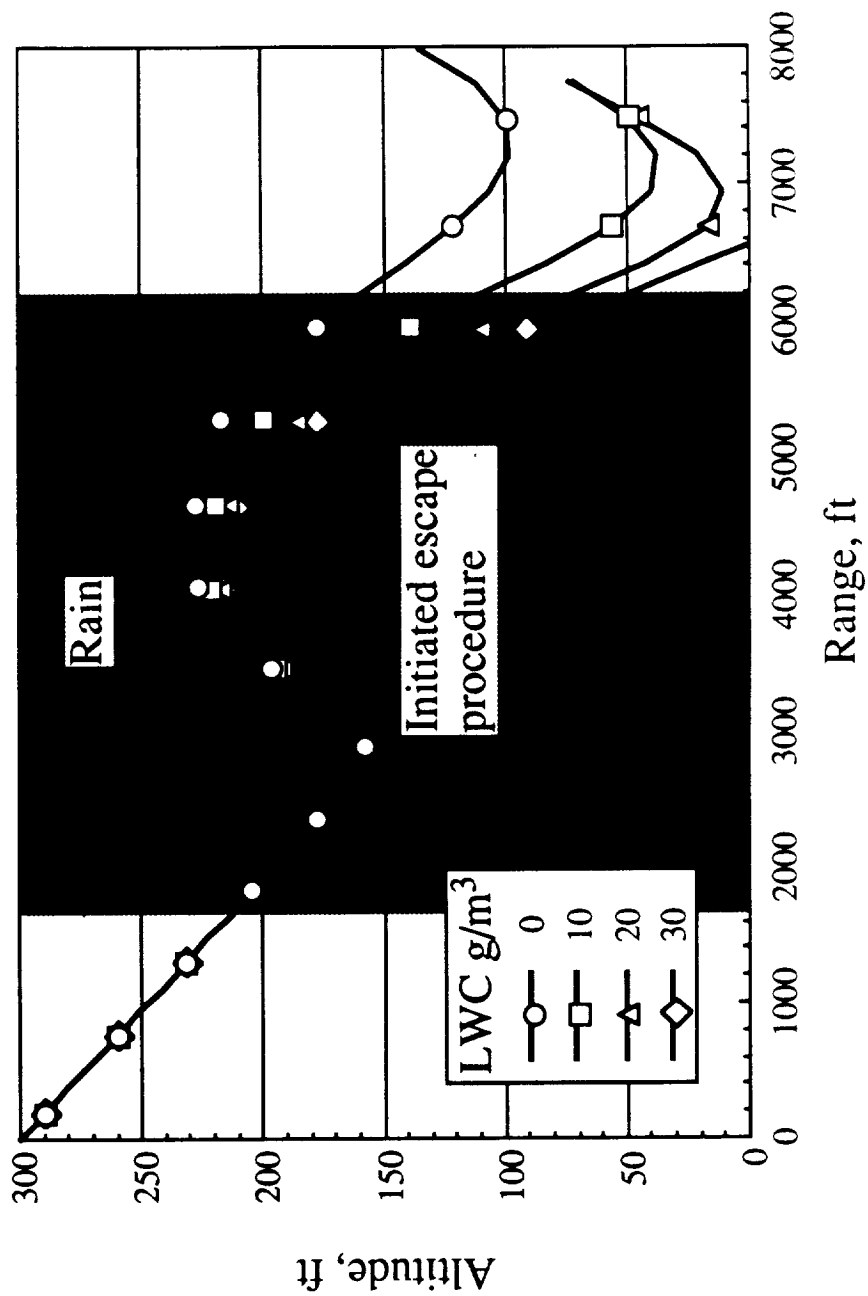
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Wet Microburst Encounter on Take-off



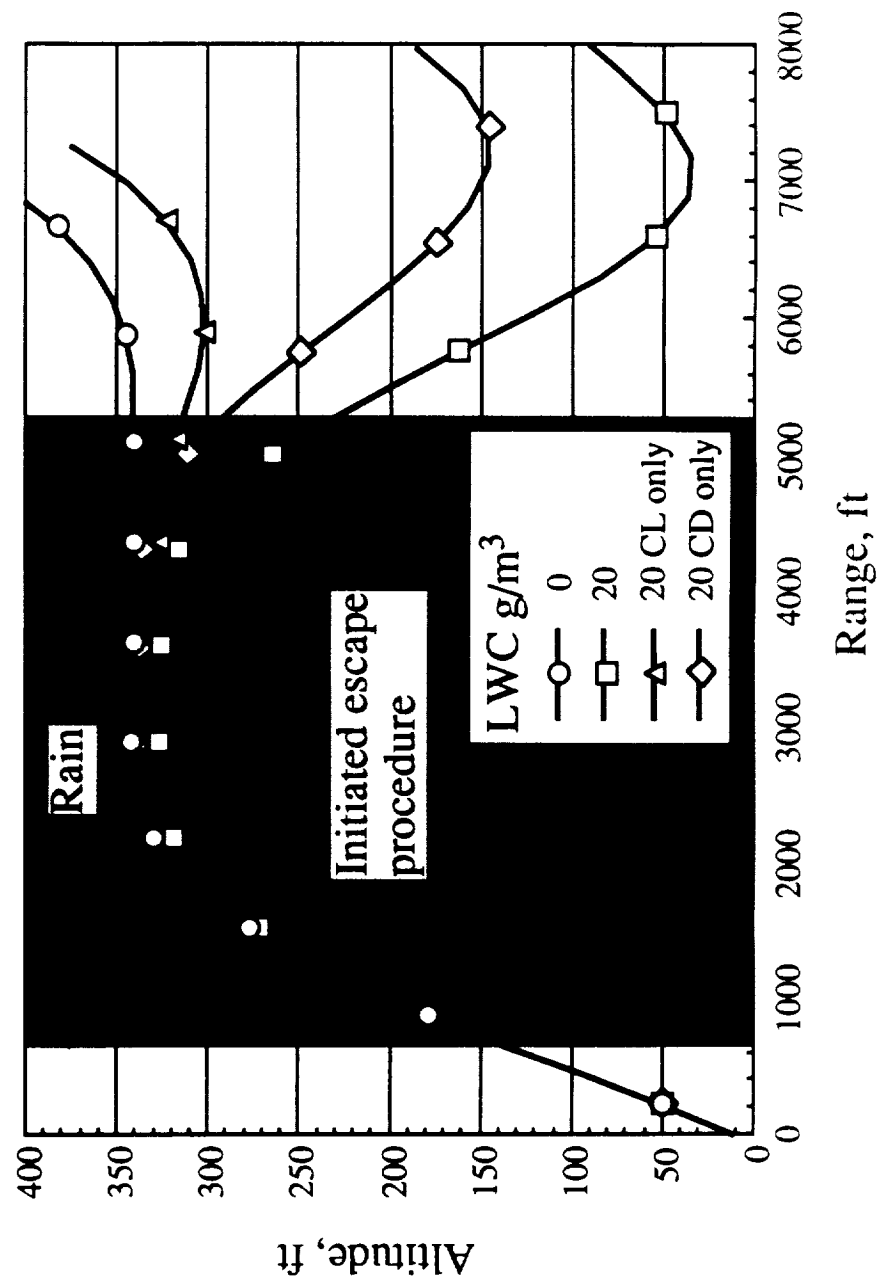
The Aerodynamic Effect of Heavy Rain on Airplane Performance

Wet Microburst Encounter on Approach



The Aerodynamic Effect of Heavy Rain on Airplane Performance

Microburst Escape Sensitivity to Lift and Drag



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The Aerodynamic Effect of Heavy Rain on Airplane Performance

Summary of Results

- The reduction in maximum lift capability and stall angle, as well as the increased drag of heavy rain, can substantially reduce climb performance
- Heavy rain can critically impair an airplane's ability to escape from an otherwise recoverable wind shear encounter
- The drag rise associated with heavy rain has the greater effect on wind shear recovery performance than the loss of lift

The Aerodynamic Effect of Heavy Rain on Airplane Performance

Future Needs

- This analysis was based on a limited data set and broad assumptions
- Need further testing of sub-scale and full-scale airfoil sections to determine scaling effects and flow mechanics
- Need sub-scale full configuration test
- Need information on heavy rain effect on engine performance

Estimate of Heavy Rain Performance Effect - Questions and Answers

Q: JOE YOUSSEFI (Honeywell) - Your data shows that the stall margin is reduced by approximately 2 degrees at landing flap configurations to levels on the order of 2.5 degrees. Does this represent adequate margin under turbulent conditions?

A: DAN VICROY (NASA Langley) - I can't answer that, I don't know. I would certainly think that you would raise a caution flag when your margin has been reduced to about half. I don't know how the stick shaker angle of attack is established and whether or not they account for a margin for turbulence. Like I said, I'd raise a caution flag in any case.

Q: JOE YOUSSEFI (Honeywell) - Should the training aid guidelines be revised relative to operation at stick shaker prior to accumulation of additional heavy rain data?

A: DAN VICROY (NASA Langley) - I'd have to say no. We just don't know enough yet to make those kind of changes. When you look at the data base that the training aid was developed with compared to the data base we've developed in the heavy rain research, we just do not know enough yet about heavy rain to make those kind of decisions.

Session VII. 2nd Generation Reactive Systems

